GRO: Project Team

Nanditha Veeraraghavelu
Architect

Sarah Centini
Landscape Architect

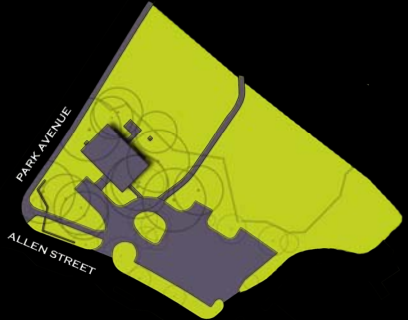
Carl Hubben
Structural Engineer

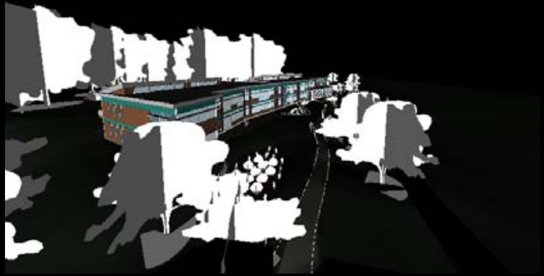
Michael Gilroy
Mechanical Engineer

Jason Brognano
Lighting/Electrical Engineer

Justin Green
Construction Manager


PARK AVENUE
ALLEN ROAD
ATHERTON STREET

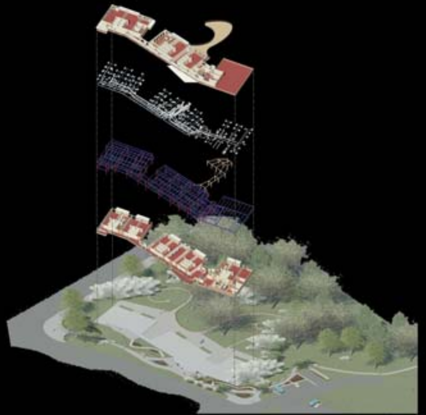

PARK AVENUE
ALLEN STREET



Architecture
- Design with respect to Hort Woods
- Create spaces for childhood growth and learning
- Efficient layout due to site restrictions

Landscape
- Strong campus connections
- Natural play environment and equipment
- Green roof and rainwater harvesting

Lighting/Electrical
- Daylight delivered wherever possible
- Electric light integral to architecture and HVAC
- Simple power distribution with restricted access

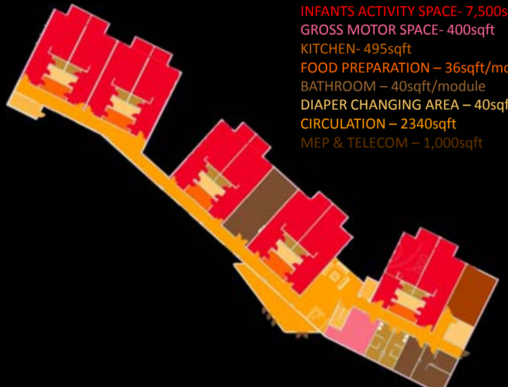


Structural
- Recycled steel with metal deck and lightweight concrete
- Braced frames
- Pinned connections

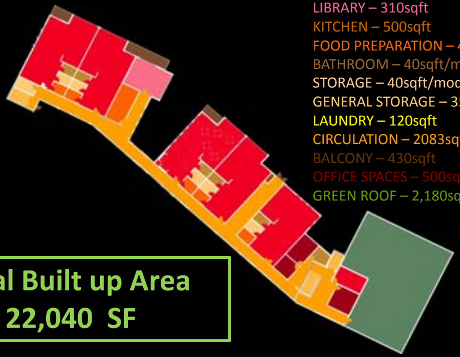
Mechanical
- Chilled beam, radiant floor heating, and DOAS system
- Centrally located mechanical room
- 25% Energy savings from typical design

Construction
- Site constraints impacted schedule and logistics
- Added costs associated with sustainable approach
- Clash detect building systems and develop 4D model

UNCOVERED OUTDOOR SPACE-42,554 sqft
COVERED OUTDOOR SPACE- 2,420 sqft

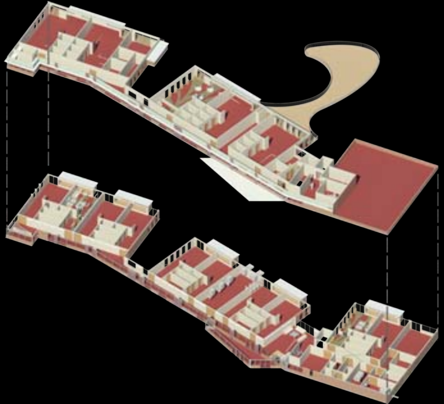


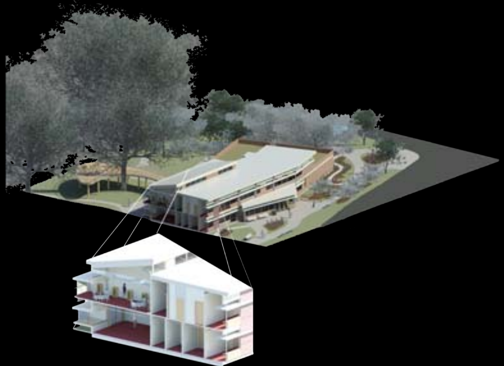
INFANTS ACTIVITY SPACE- 7,500sqft
GROSS MOTOR SPACE- 400sqft
KITCHEN- 495sqft
FOOD PREPARATION – 36sqft/module
BATHROOM – 40sqft/module
DIAPER CHANGING AREA – 40sqft/module
CIRCULATION – 2340sqft
MEP & TELECOM – 1,000sqft



PRESCHOOL ACTIVITY SPACE – 6,000sqft
LIBRARY – 310sqft
KITCHEN – 500sqft
FOOD PREPARATION – 40sqft/module
BATHROOM – 40sqft/module
STORAGE – 40sqft/module
GENERAL STORAGE – 350sqft
LAUNDRY – 120sqft
CIRCULATION – 2083sqft
BALCONY – 430sqft
OFFICE SPACES – 500sqft
GREEN ROOF – 2,180sqft

Total Built up Area
22,040 SF



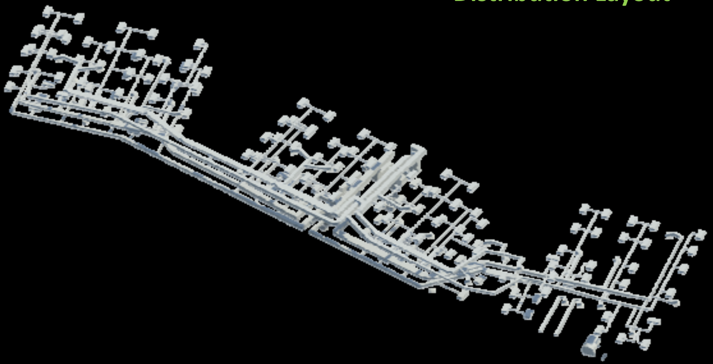


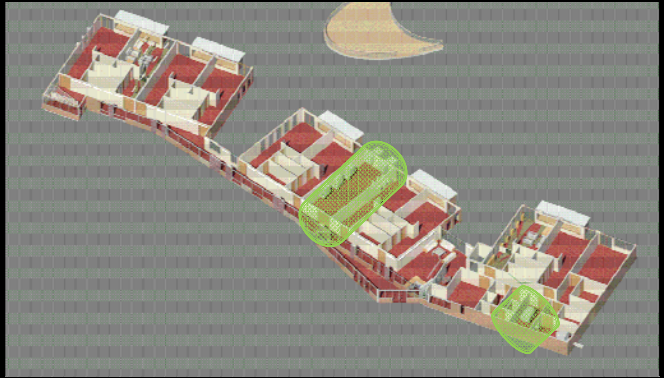
Structural and Architectural Coordination

Slight modification to classroom module

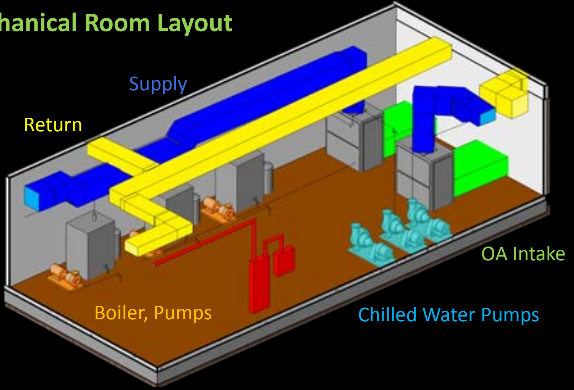
- **Consistent bay spans**
- **Interior lateral bracing**

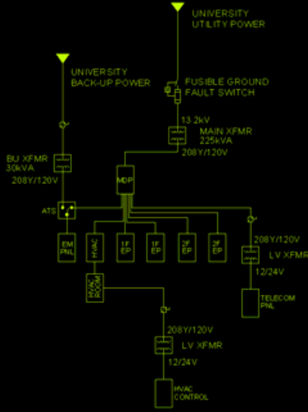
Distribution Layout





Mechanical Room Layout



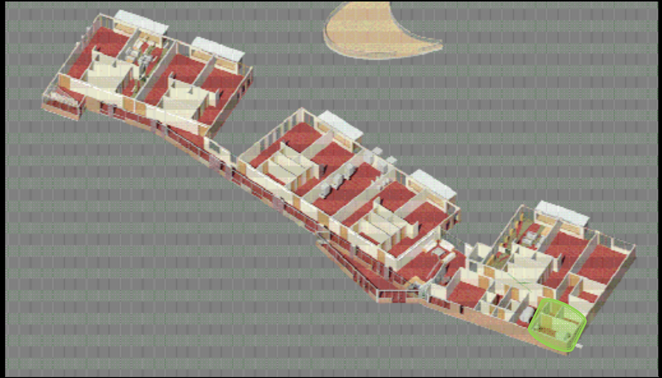


Special Considerations

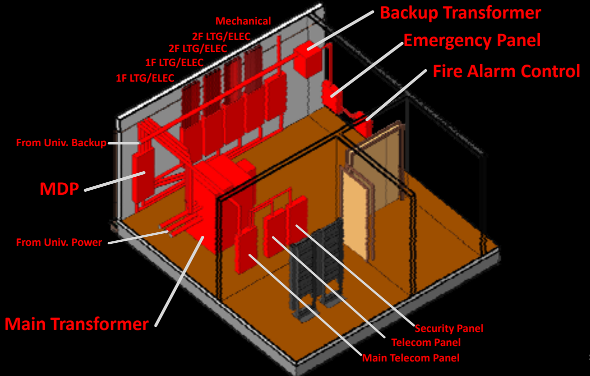
Restricted access to both rooms

Fire alarm system
Security CCTV system
Telecom equipment

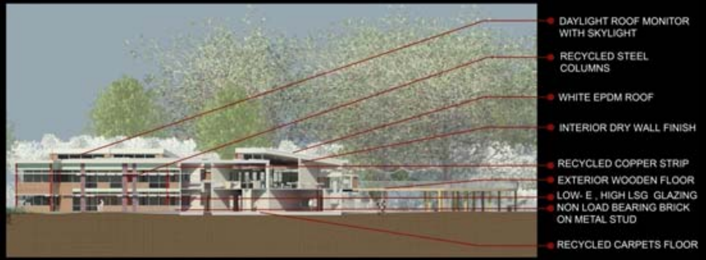
Panelboard costs



Electrical/Telecom Room Layout

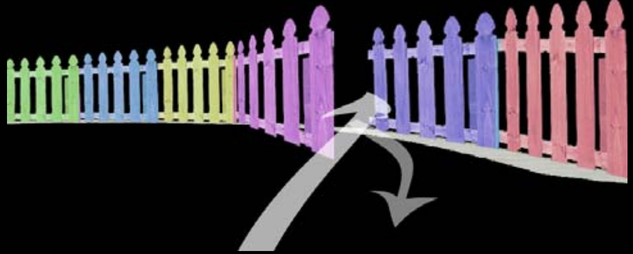


Some Items omitted to reduce clutter


DAYLIGHT ROOF MONITOR WITH SKYLIGHT
RECYCLED STEEL COLUMNS
WHITE EPDM ROOF
INTERIOR DRY WALL FINISH
RECYCLED COPPER STRIP
EXTERIOR WOODEN FLOOR
LOW- E , HIGH LSG GLAZING
NON LOAD BEARING BRICK ON METAL STUD
RECYCLED CARPETS FLOOR


HORT WOODS
NOISE BUFFER
RAIN GARDEN
SEASONAL PLANTS

Curvilinear fencing system
provides protection
aesthetically pleasing

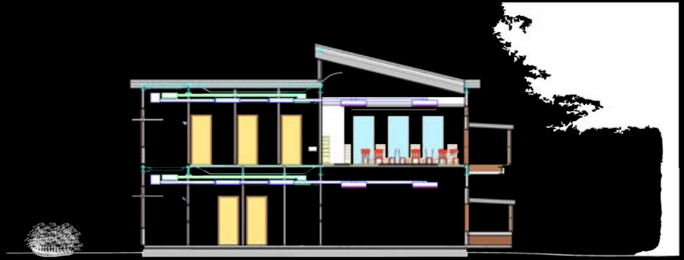


Special Considerations

Entrance to campus
Showcase stone wall
Match campus area lighting
Integral fence lighting

LARCH Experience

- Low plantings on the south side do not interfere with daylighting
- Tall plantings reserved for the north side where there will be no interference with daylighting



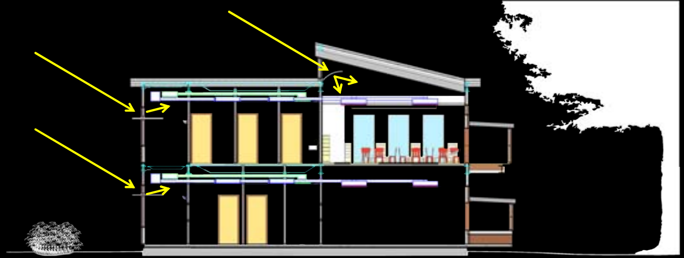
Lighting Experience

- Daylight delivery from above on the second floor
- Ample view to the outside on all floors
- Ambient reflectance to the first floor

LARCH Experience

Low plantings on the south side do not interfere with daylighting

Tall plantings reserved for the north side where there will be no interference with daylighting



Lighting Experience

① Summer Solstice – hottest summer sun does not penetrate the spaces under exterior light shelf

② Winter Solstice – low winter angle glare is avoided due to interior shelf

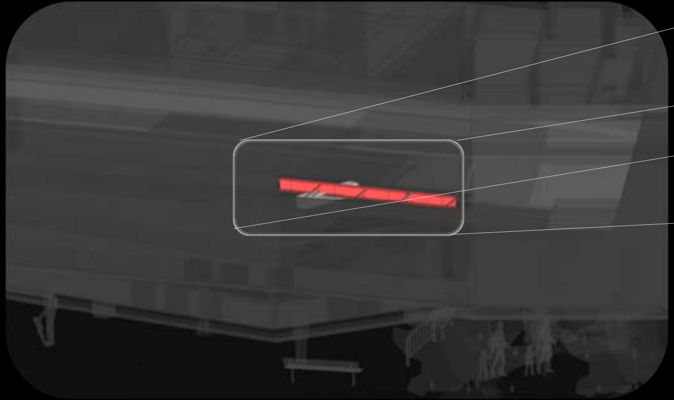
Navisworks Experience

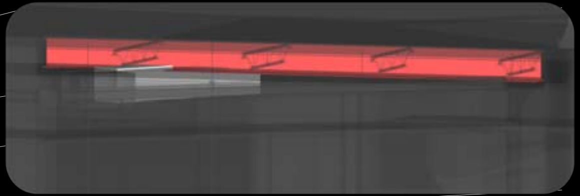
Identified constructability issues before they occur

Helped identify ceiling cavity requirements

Issues with Revit exports, origins

Simplified duct model used





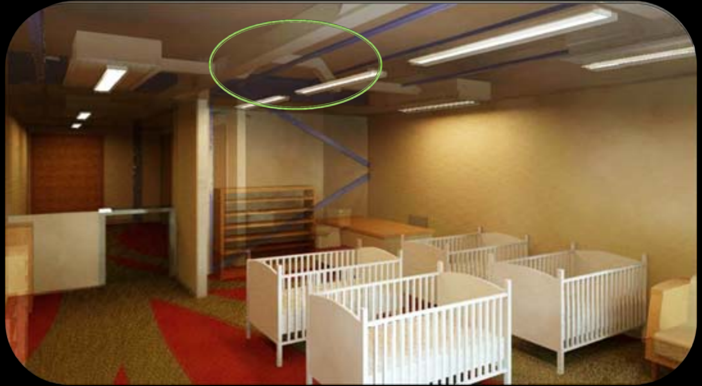
Supply Air Duct clipping bottom with a structural beam

Revit Experience

Structural System vs. Mechanical System

Chilled beam supply clash with bottom chord of joist

Adjusted in Revit MEP to go through opening in joist



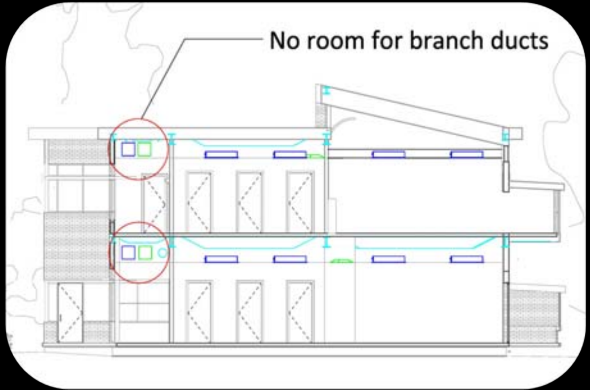
PROBLEM: Ceiling space inadequate for HVAC ducts

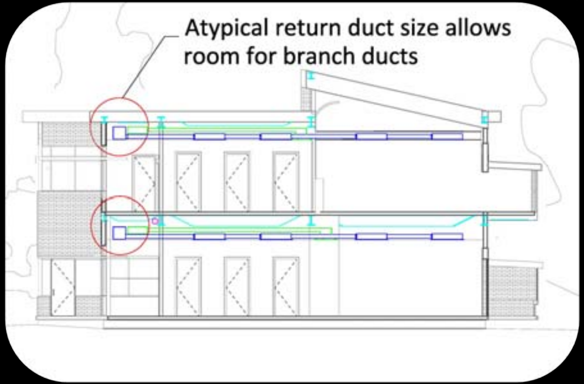
Custom Wall ‘s height unable to be changed easily

Topography in place and time consuming to change

SOLUTION: Change duct aspect ratio per ASHRAE Fundamentals

Shallow structural members above largest duct runs





PROBLEM: Chilled Beam in 2nd story classroom

Chilled Beam needs air, chilled water supplied and returned

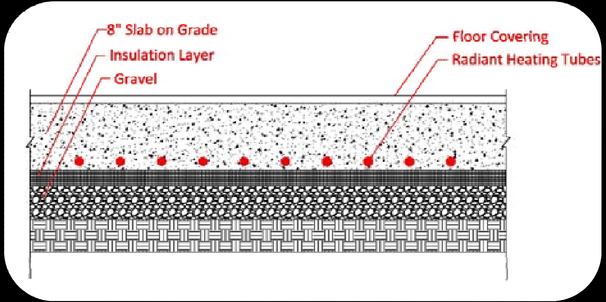
Roof monitor integrity and integration into structural module

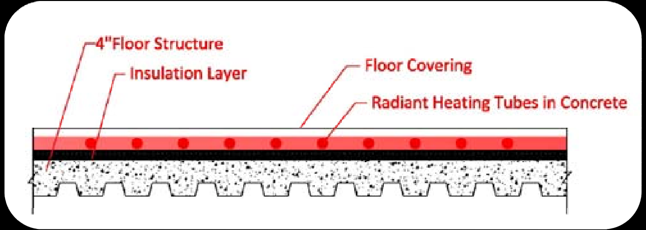
SOLUTION: False beam system allows use of chilled beams and creates unique view towards source of daylighting

Radiant Floor Heating System

Cons: Coordination with floor systems
Cost and schedule impact
Extra material and specialty installation

Pros: Reduced energy usage
Heat delivered to occupant level
Thermally comfortable





Energy Modeling Process

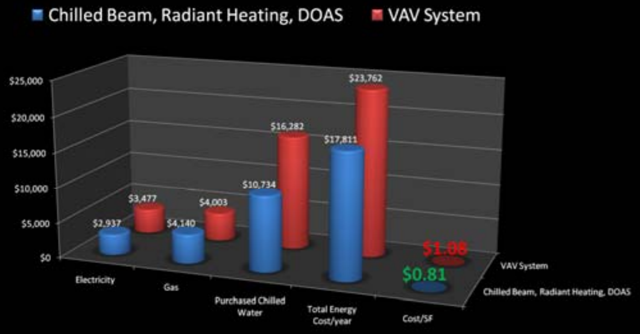
Revit Architecture: Room geometries

↓

Trane TRACE: Fix export errors, System assignments

↓

Address discrepancies, compare alternatives= Final Model



Operating Cost Comparison

25% Reduction in operating costs

$5,951 in yearly savings

Potentially more but TRACE didn't model heating system as radiant floor heating

Uponor estimates up to 40% energy savings

20% Reduction in CO_2,SO_2, and NO_x emissions

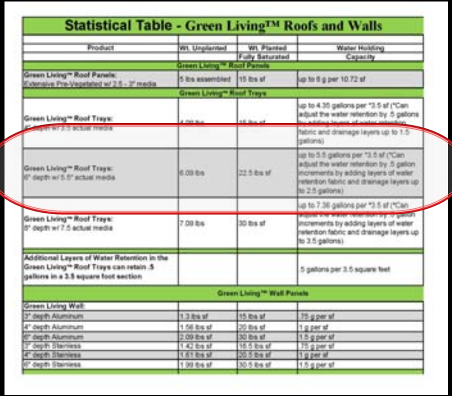
Green Roof

Located on southern wing for maximum natural light

Structural concern with complete green roof

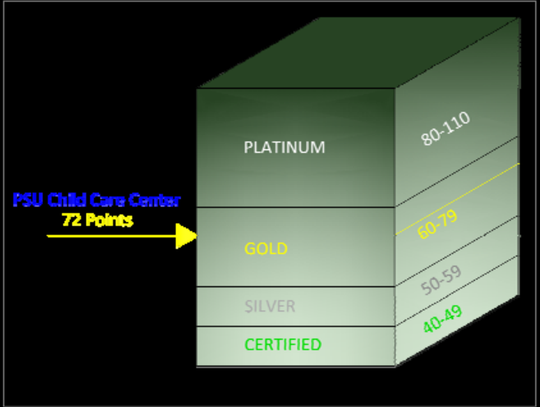
Cost issues with complete green roof

Access to building occupants



Statistical Table - Green Living™ Roofs and Walls

Product	Wt. Unplanted	Wt. Planted Fully Saturated	Water Holding Capacity
Green Living™ Roof Panels			
Green Living™ Roof Panels: Extensive Pre-Vegetated w/ 2.5 - 3" media	5 lbs assembled	15 lbs sf	up to 8 g per 10.72 sf
Green Living™ Roof Trays			
Green Living™ Roof Trays: 4" depth w/ 3.5 actual media	4.09 lbs	15 lbs sf	up to 4.35 gallons per *3.5 sf (*Can adjust the water retention by .5 gallons by adding layers of water retention fabric and drainage layers up to 1.5 gallons)
Green Living™ Roof Trays: 6" depth w/ 5.5" actual media	6.09 lbs	22.5 lbs sf	up to 5.5 gallons per *3.5 sf (*Can adjust the water retention by .5 gallon increments by adding layers of water retention fabric and drainage layers up to 2.5 gallons)
Green Living™ Roof Trays: 8" depth w/ 7.5 actual media	7.09 lbs	30 lbs sf	up to 7.36 gallons per *3.5 sf (*Can adjust the water retention by .5 gallon increments by adding layers of water retention fabric and drainage layers up to 3.5 gallons)
Additional Layers of Water Retention in the Green Living™ Roof Trays can retain .5 gallons in a 3.5 square foot section			.5 gallons per 3.5 square feet
Green Living™ Wall Panels			
Green Living Wall:			
3" depth Aluminum	1.3 lbs sf	15 lbs sf	.75 g per sf
4" depth Aluminum	1.56 lbs sf	20 lbs sf	1 g per sf
6" depth Aluminum	2.09 lbs sf	30 lbs sf	1.5 g per sf
3" depth Stainless	1.42 lbs sf	16.5 lbs sf	.75 g per sf
4" depth Stainless	1.61 lbs sf	20.5 lbs sf	1 g per sf
6" depth Stainless	1.99 lbs sf	30.5 lbs sf	1.5 g per sf



LEED 2009 Project Checklist	
Sustainable Sites	22/26 Points
Water Efficiency	7/10 Points
Energy and Atmosphere	21/35 Points
Materials and Resources	8/14 Points
Indoor Environmental Quality	13/15 Points
Innovation and Design Process*	1/6 Points
Regional Priority Credits*	0/4 Points
LEED Gold Certification	72/110 Points

Highlights

Green Roof

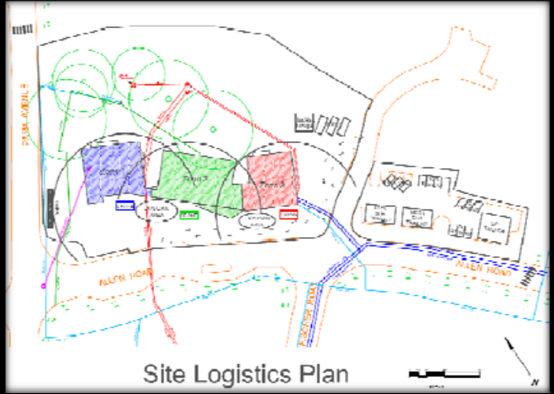
Rainwater Harvesting

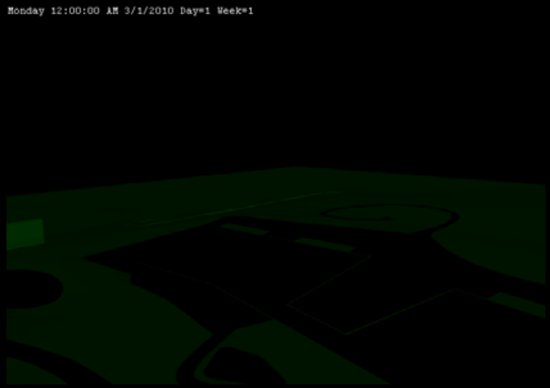
Reduce heat island effect with cool roof

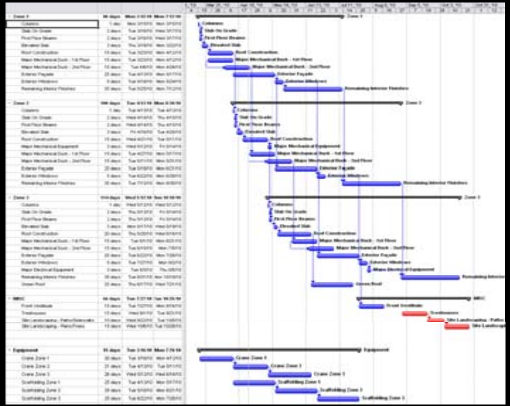
Recycled Materials

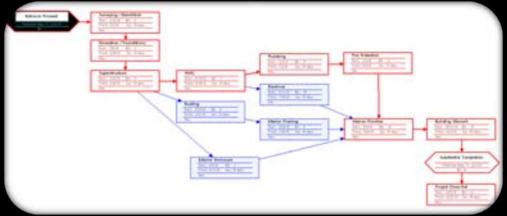
Daylighting strategies

Context | Design | Coordination | Green Performance | **Constructability** | BIM/IPD | Reflections





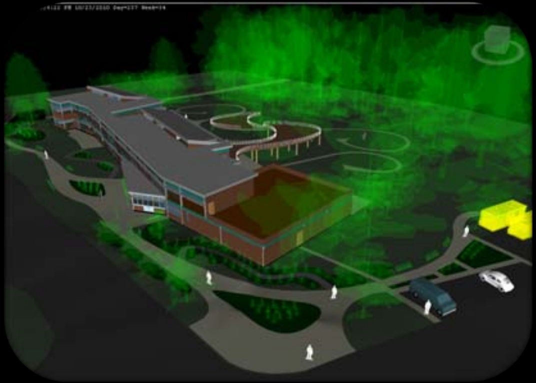


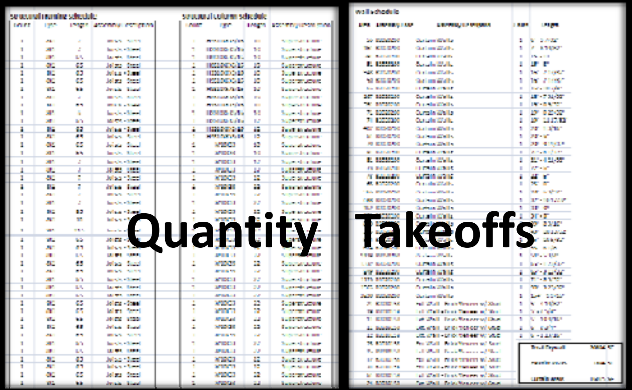


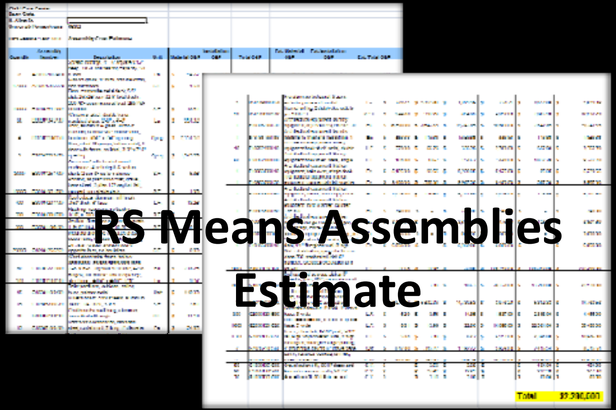
PSU CHILD CARE CENTER

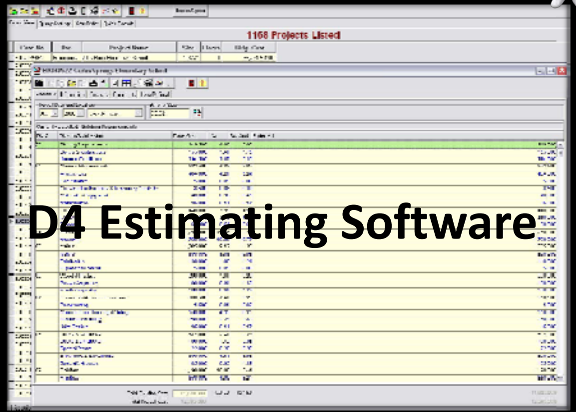
PROJECT TEAM KEY SCHEDULE DATES

ACTIVITY	LATE START	LATE FINISH	DURATION
Notice to Proceed	2/12/2010	2/12/2010	1 Day
Start Site Clearing	2/12/2010	3/5/2010	16 Days
Pour Footings	3/8/2010	3/26/2010	15 Days
Complete Exterior Building Construction	3/15/2010	6/11/2010	~3 Months
Complete Interior Building Construction	4/19/2010	10/8/2010	~6 Months
Complete Exterior Site Construction	10/11/2010	12/3/2010	~2 Months
Project Substantial Completion	12/3/2010	12/3/2010	1 Day
Project Close Out	12/6/2010	12/31/2010	~1 Month
		TOTAL PROJECT DURATION	10.5 Months

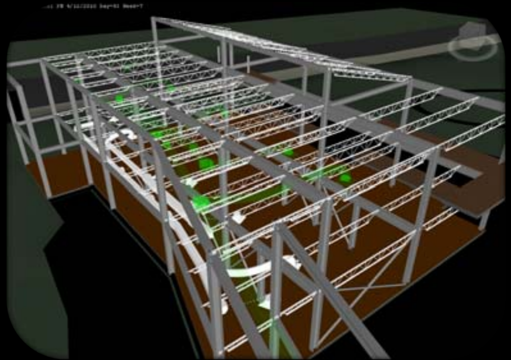


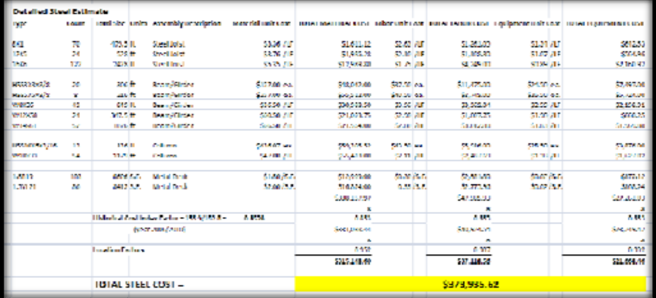

Quantity Takeoffs

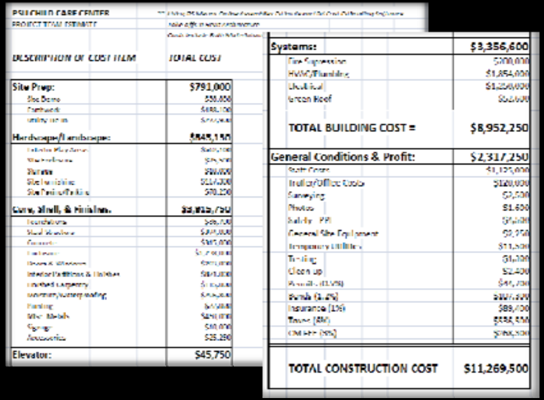

RS Means Assemblies Estimate


1168 Projects Listed
D4 Estimating Software

Context | Design | Coordination | Green Performance | **Constructability** | BIM/IPD | Reflections







BIM Goals

vs.

BIM Uses

Conceptual Design

BIM Goals:
- Site Analysis
- Design Review
- Existing Conditions Modeling
- Record Modeling
- File Updating

BIM Uses:
- Building Mass Modeling
- Site Analysis

Design Development

BIM Goals:
- Design Authoring
- Design Review and Constructability
- Structural, Lighting, Energy, Mechanical Analysis
- LEED Evaluation
- 3D Coordination
- 4D Modeling

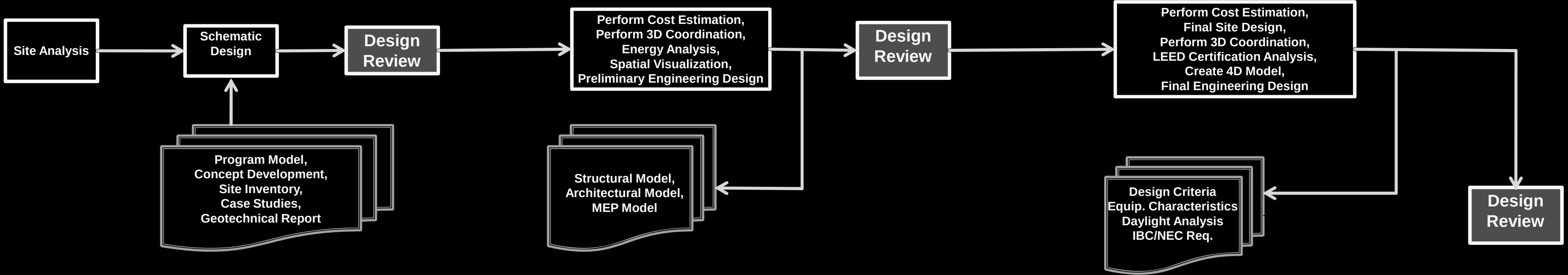
BIM Uses:
- Structural, Lighting, Mechanical Design
- 3D Coordination
- File Updating

Final Design

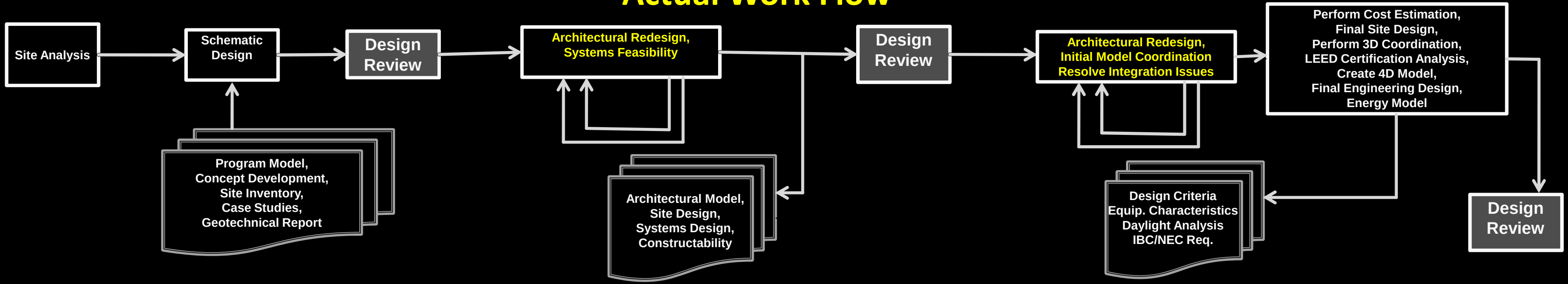
BIM Goals:
- Site Utilization Planning
- 4D Modeling
- Programming
- 3D Coordination
- Cost Estimation
- File Updating

BIM Uses:
- Energy Analysis
- Site Utilization Planning
- 4D Modeling
- 3D Coordination
- Cost Estimation
- File Updating

Planned Work Flow



Actual Work Flow



Discipline	Software	Uses
Architectural	Revit Architecture, Ecotect	Space layout, appearance
Landscape Architectural	Revit Architecture, AutoCAD	Building's response to site
Structural	Revit Structure, SAP 2000	3D coordination, analysis, layout
Mechanical	Revit MEP, Trane TRACE	3D coordination, layout, energy modeling
Lighting/Electrical	Revit Architecture	Layout, rendering
Construction Management	Navisworks, Revit Architecture	Estimates, Scheduling, 4D Modeling, Clash Detection

LESSONS LEARNED

…BIM

Linked files favored over worksets

Coordinate files often

BIM Ex Plan more applicable in real world than classroom simulation

Revit MEP
- Duct & fitting clashes
- Slow to make connections
- Difficult to adjust height of system as whole

Revit Structure
- Poor connections
- Limited analysis options

Revit Architecture
- Site modeling issues
- Rendering time
- No analysis for lighting systems
- Trouble joining elements

Trane TRACE
- Import issues from Revit
- Discrepancies in results
- Need to carefully examine all parameters

Navisworks
- Difficult to 4-D model with structure in central file as opposed to a linked separate file
- Discrepancies in origins of imported files

LESSONS LEARNED

...IPD

Challenges & Solutions

Interdisciplinary arguments
→ **Reason with team the best alternative for building**
Meeting time difficult to coordinate
→ **Coordinating schedules and effective communication while working separately**
Presenting as individuals instead of team
→ **Integrate concepts and ideas in presentations**

Final Thoughts

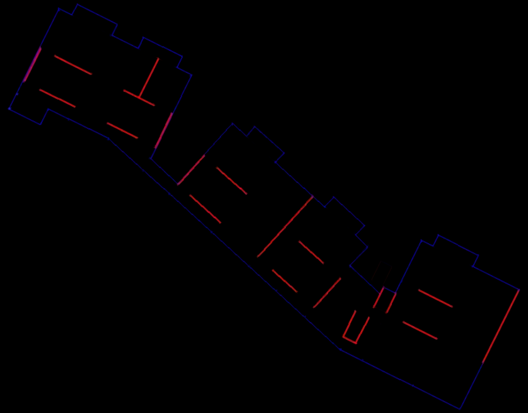
At the end of the semester, our group agrees that the IPD/BIM process is labor intensive but has clear advantages over other delivery methods.

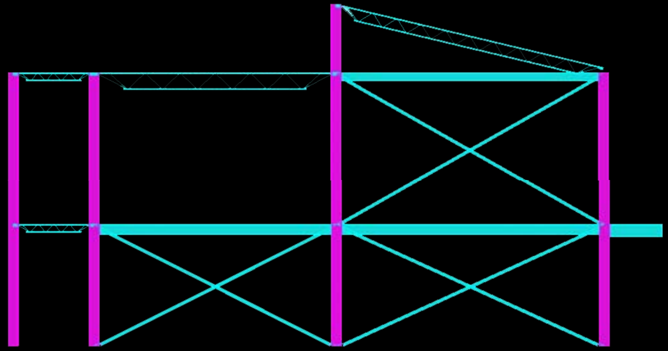
We feel that many of the issues encountered throughout the semester were one time learning mistakes. A second time through would be much more seamless.

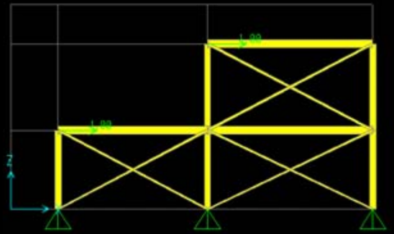
The BIM/IPD process offers a unique learning opportunity and insight into all disciplines involved in the building industry.

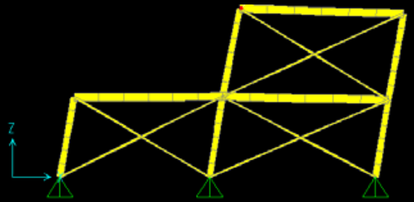
Questions…

Lateral System









ASHRAE Ventilation Requirements

10 CFM per person, 0.18 per SF
1st Floor: ~ 100 people, 12,000 SF = 3160 CFM ~ 4000 CFM AHU
2nd Floor: ~100 people, 10,000 SF = 2800 CFM ~ 3000 CFM AHU

Actual Ventilation to Handle Cooling Load

75 DB, 50% RH assume desired space conditions

OA Design Condition
82 DB / 73.2 DB
0.0155 lb vapor/lb air

EA Design Conditon
79 DB
0.0106 lb vapor/lb air

After enthalpy wheel
79.45 DB
0.01134 lbvapor/lbair

After cooling coil : 45 DB, ~100% RH, 0.0063 lb vapor/lb air

Ventilation per ASHRAE Standard, typ classroom = 250 CFM
Ventilation per calculation to meet latent load = 300 CFM

Rule of thumb applied to all spaces:
1.2 x ASHRAE standard will handle latent load

1.3 Factor would give us another LEED point for extra ventilation, however it may not be worth the extra energy costs.

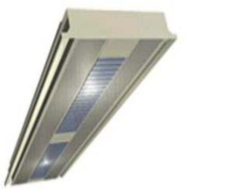
Total Sensible Load for typ. infant classroom: 40,000 BTU/hr
Total Sensible Load for typ. Preschool classroom: 51,000 BTU/hr

Q_sen_SA= 1.08 *Volume of SA*(Tsp-Tsa)
=1.08 (300)*(75-45)
=9720 BTU/hr for infant classroom
=16,200 BTU/hr for preschool classroom

Difference for infant classroom = 30,000 Btu/hr
Difference for preschool classroom = 35,000 BTU/hr

1610 W per chilled beam x 3.412 Btu/h per watt = 5,500 BTU/hr per chilled beam
=Roughly 6 Chilled Beam per classroom
=50 cfm/chilled beam at infant
=83.33 cfm/chilled beam at preschool

Type DID600B-L



Multi-service active chilled beam
Flush-mounted in the ceiling
Integrated linear light fittings
Low height construction
Top or side entry spigot for fresh air
Heat exchanger horizontal
Project bespoke dimensions

more details

rectangular

primary air:
3 – 43 l/s
11 – 155 m³/h

L: 1500 – 3000 mm
W: 593 mm
H: 210 mm

Cooling capacity up to 1610 W
Heating capacity up to 1730 W

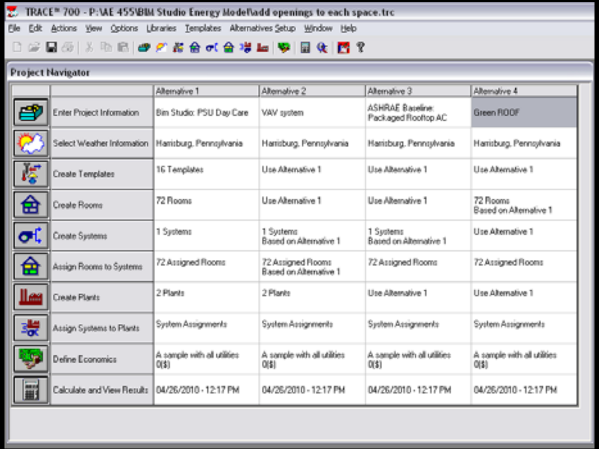
TABLE G3.1.1A Baseline HVAC System Types

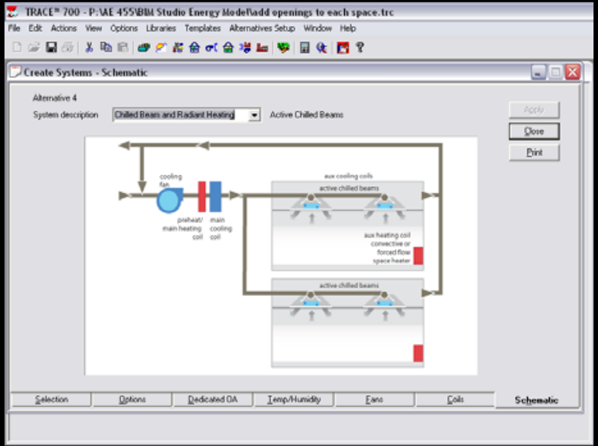
Building Type	Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat	Electric and Other
Residential	System 1—PTAC	System 2—PTHP
Nonresidential and 3 Floors or Less and <25,000 ft^2	System 3—PSZ-AC	System 4—PSZ-HP
Nonresidential and 4 or 5 Floors and <25,000 ft^2 or 5 Floors or Less and 25,000 ft^2 to 150,000 ft^2	System 5—Packaged VAV with Reheat	System 6—Packaged VAV with PFP Boxes
Nonresidential and More than 5 Floors or >150,000 ft^2	System 7—VAV with Reheat	System 8—VAV with PFP Boxes

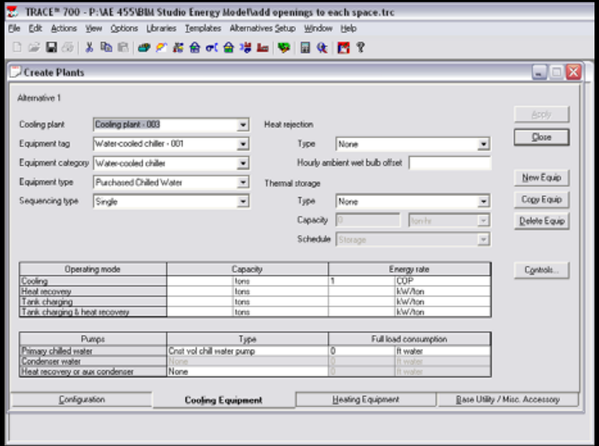
Notes:
Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.
Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.
Where attributes make a building eligible for more than one baseline system type, use the predominant condition to determine the system type for the entire building.
For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 and reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

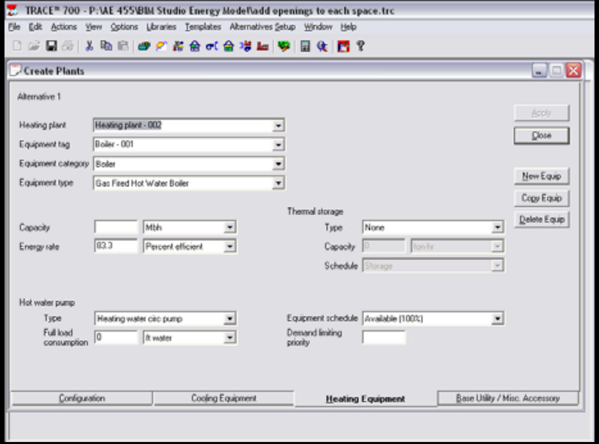
TABLE G3.1.1B Baseline System Descriptions

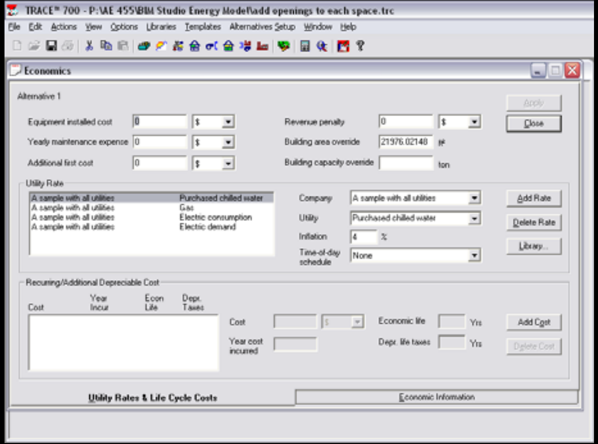
System No.	System Type	Fan Control	Cooling Type	Heating Type
1. PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot-water fossil fuel boiler
2. PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Direct expansion	Hot-water fossil fuel boiler
6. Packaged VAV with PFP Boxes	Packaged rooftop VAV with reheat	VAV	Direct expansion	Electric resistance
7. VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Chilled water	Hot-water fossil fuel boiler
8. VAV with PFP Boxes	VAV with reheat	VAV	Chilled water	Electric resistance

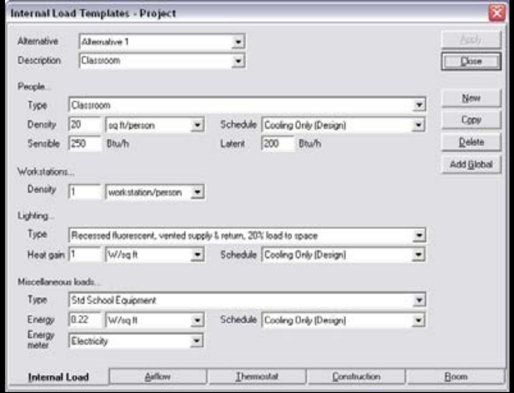

TRACE™ 700 - P:\AE 455\BIM Studio Energy Model\add openings to each space.trc
Project Navigator
Alternative 1
Alternative 2
Alternative 3
Alternative 4
Enter Project Information
Bim Studio: PSU Day Care
VAV system
ASHRAE Baseline: Packaged Rooftop AC
Green ROOF
Select Weather Information
Harrisburg, Pennsylvania
Create Templates
16 Templates
Use Alternative 1
Create Rooms
72 Rooms
72 Rooms Based on Alternative 1
Create Systems
1 Systems
1 Systems Based on Alternative 1
Assign Rooms to Systems
72 Assigned Rooms
72 Assigned Rooms Based on Alternative 1
Create Plants
2 Plants
Assign Systems to Plants
System Assignments
Define Economics
A sample with all utilities 0($)
Calculate and View Results
04/26/2010 - 12:17 PM

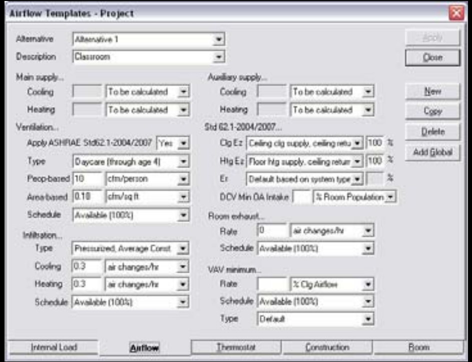

TRACE™ 700 - P:\AE 455\BIM Studio Energy Model\add openings to each space.trc
Create Systems - Schematic
Alternative 4
System description
Chilled Beam and Radiant Heating
Active Chilled Beams
Apply
Close
Print
cooling fan
preheat/ main heating coil
main cooling coil
aux cooling coils
active chilled beams
aux heating coil convective or forced flow space heater
active chilled beams
Selection
Options
Dedicated OA
Temp/Humidity
Fans
Coils
Schematic


TRACE™ 700 - P:\AE 455\BIM Studio Energy Model\add openings to each space.trc
Create Plants
Alternative 1
Cooling plant
Cooling plant - 003
Equipment tag
Water-cooled chiller - 001
Equipment category
Water-cooled chiller
Equipment type
Purchased Chilled Water
Sequencing type
Single
Heat rejection
Type
None
Hourly ambient wet bulb offset
Thermal storage
Type
None
Capacity
Schedule
Storage
Apply
Close
New Equip
Copy Equip
Delete Equip
Controls...
Operating mode
Capacity
Energy rate
Cooling
Heat recovery
Tank charging
Tank charging & heat recovery
tons
COP
kW/ton
Pumps
Type
Full load consumption
Primary chilled water
Cnst vol chill water pump
ft water
Condenser water
Heat recovery or aux condenser
None
Configuration
Cooling Equipment
Heating Equipment
Base Utility / Misc. Accessory


TRACE™ 700 - P:\AE 455\BIM Studio Energy Model\add openings to each space.trc
File Edit Actions View Options Libraries Templates Alternatives Setup Window Help
Create Plants
Alternative 1
Heating plant
Heating plant - 002
Equipment tag
Boiler - 001
Equipment category
Boiler
Equipment type
Gas Fired Hot Water Boiler
Apply
Close
New Equip
Copy Equip
Delete Equip
Capacity
Mbh
Energy rate
83.3
Percent efficient
Thermal storage
Type
None
Capacity
Schedule
Storage
Hot water pump
Type
Heating water circ pump
Full load consumption
0
ft water
Equipment schedule
Available (100%)
Demand limiting priority
Configuration
Cooling Equipment
Heating Equipment
Base Utility / Misc. Accessory


TRACE™ 700 - P:\AE 455\BIM Studio Energy Model\add openings to each space.trc
File Edit Actions View Options Libraries Templates Alternatives Setup Window Help
Economics
Alternative 1
Equipment installed cost
0
$
Yearly maintenance expense
0
$
Additional first cost
0
$
Revenue penalty
0
$
Building area override
21976.02148
ft²
Building capacity override
ton
Apply
Close
Utility Rate
A sample with all utilities
Purchased chilled water
A sample with all utilities
Gas
A sample with all utilities
Electric consumption
A sample with all utilities
Electric demand
Company
A sample with all utilities
Utility
Purchased chilled water
Inflation
4
%
Time-of-day schedule
None
Add Rate
Delete Rate
Library...
Recurring/Additional Depreciable Cost
Cost
Year Incur
Econ Life
Depr. Taxes
Cost
Year cost incurred
Economic life
Yrs
Depr. life taxes
Yrs
Add Cost
Delete Cost
Utility Rates & Life Cycle Costs
Economic Information


Internal Load Templates - Project
Alternative
Alternative 1
Description
Classroom
Apply
Close
People
Type
Classroom
Density
20
sq ft/person
Schedule
Cooling Only (Design)
Sensible
250
Btu/h
Latent
200
Btu/h
New
Copy
Delete
Add Global
Workstations
Density
1
workstation/person
Lighting
Type
Recessed fluorescent, vented supply & return, 20% load to space
Heat gain
1
W/sq ft
Schedule
Cooling Only (Design)
Miscellaneous loads
Type
Std School Equipment
Energy
0.22
W/sq ft
Schedule
Cooling Only (Design)
Energy meter
Electricity
Internal Load
Airflow
Thermostat
Construction
Room



Energy Consumption	Chilled Beam	VAV System	ASHRAE Baseline
Electric Heating (kWh)	5,637	13,572	6,506
Gas Heating (kBTU)	828,015	800,687	1,443,921
Chilled Water Compressor (kBTU)	1,073,391	1,628,159	1,210,978
Others (kWh)	40,107	40,107	36,603
Total	2,055,963	2,608,334	
Trace Total (kBTU/yr)	2,057,529	2,612,050	2,802,029
Cost	Chilled Beam, Radiant	VAV System	
Electricity	$2,937	$3,477	
Gas	$4,140	$4,003	
Purchased Chilled Water	$10,734	$16,282	
Total Energy Cost/year	$17,811	$23,762	
Cost/SF	$0.81	$1.08	
Percentage Savings to VAV	0.250441882		
Yearly Savings	$5,951		
Percentage Savings to 90.1 Baseline	0.265700319		
Area ft2	21,976		
Percent Reduction in Emissions to VAV	0.212292364		
Percent Reduction in Emissions to 90.1	0.265700445		

Chilled Beam	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric	4150	3749	4150	4016	3685	3296	3566	3468	3566	4088	4016	4150	45744
Gas	1669	1542	1148	600	101	0	0	6	87	641	939	1548	8280
Purchase Chilled Water	9	13	13	129	1210	2176	3573	2216	1175	176	39	6	10734

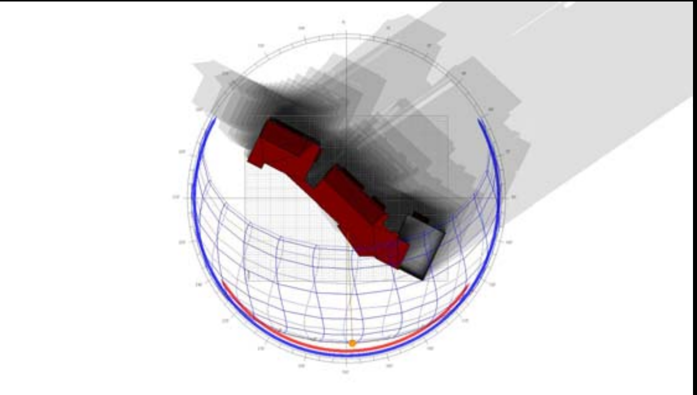
Energy Consumption		Enivronment Impact Analysis	
Building	93,626 Btu/ft2-year	CO2	733,200
Source	98,548 Btu/ft2/year	SO2	5,669
		NOX	1,139
		Total	740,008

VAV	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric	4919	4443	4919	4760	4288	3845	3721	4036	4150	4919	4760	4919	53678
Gas	1263	1133	999	725	330	125	34	163	331	777	925	1202	8007
Purchase Chilled Water	75	68	94	401	1996	3189	4252	3217	2143	535	233	80	16282

Energy Consumption		Enivronment Impact Analysis	
Building	118,8859 Btu/ft2/year	CO2	930,803
Source	120,355	SO2	7,196
		NOX	1,446
		Total	939,445

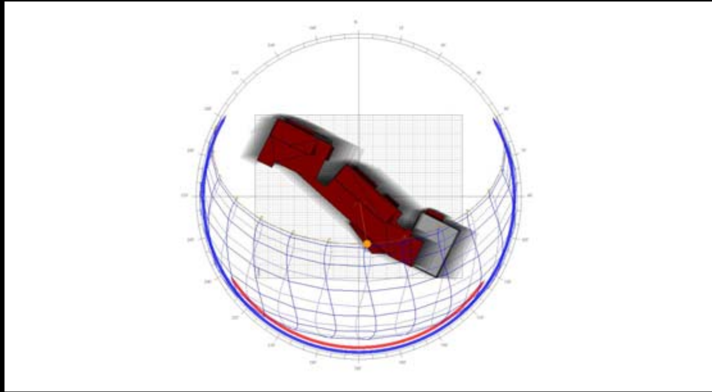
90.1 Baseline		Environmental Impact Analysis	
Energy Consumption	127,504	CO2	998,502
source	131,638	SO2	7,720
		NOX	1,552
		Total	1,007,774

Winter Solstice Shadow Range



Ecotect Shadow Analysis

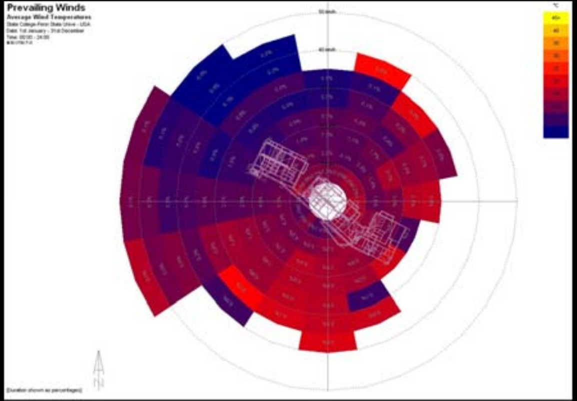
Summer Solstice Shadow Range





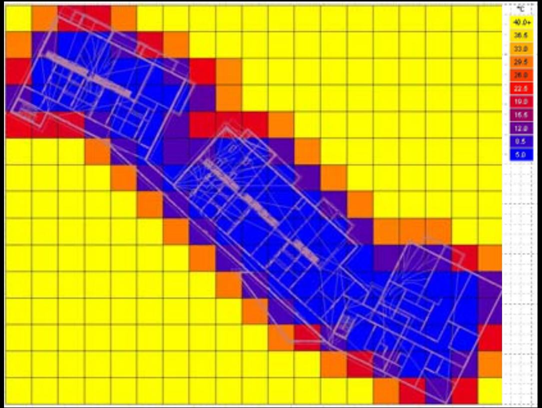
Prevailing Winds– Autodesk Ecotect

Average Wind Temperature
State College- Penn State University
Date: 1st January – 31st December



Thermal Comfort – Autodesk Ecotect

Mean Radiant Temp
Value Range: 5 – 40 degree Celcius



Lighting Analysis – Autodesk Ecotect

Daylight Factor
Value Range: 0-100%